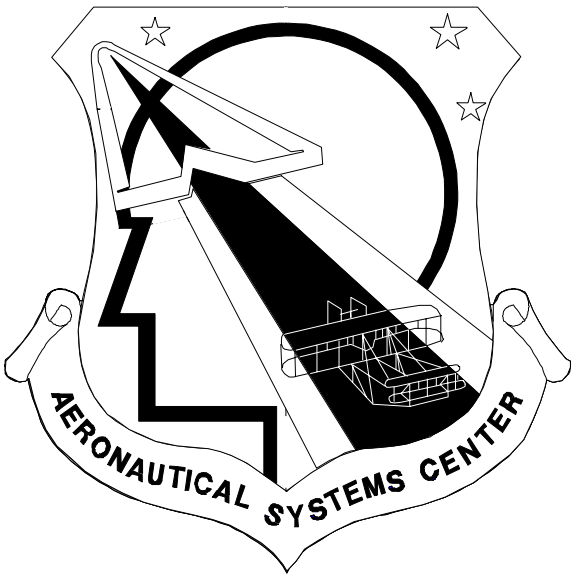
ASC-TR-2000-5009

B-1B ALTERNATIVE LAUNCH ACCEPTABILITY REGION (ALT LAR) STUDY



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JUNE, 2000

FINAL REPORT FOR JANUARY - JUNE 2000

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

ENGINEERING DIRECTORATE
AERONAUTICAL SYSTEM CENTER
AIR FORCE MATERIAL COMMAND
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

1. A human factors study was conducted on the B-1B Alternative Launch Acceptability Region (ALT LAR) displays. The study objective was to perform a human factors evaluation of B-1B ALT LAR displays and make recommendations to B-1B System Program Office Engineering (SPO) (ASC/YDE).

2. This objective was studied in the B-1B Engineering Research Simulator (ERS) in a simulated full mission environment using five B-1B crews. After training, the crews flew two missions with Weapons Systems Operators (WSO) changing positions between missions. Workload was measured, a questionnaire was given, specific mission data were collected, and all missions were video taped.

3. The main findings of the study are that:

    a. The ALT LAR displays allowed the Offensive Systems Operator (OSO) to average 92.4 percent Bombs on Target.

    b. All of the WSO ALT LAR modifications received a "Very Acceptable" rating.

    c. WSO Target Situational Awareness received a "Very Acceptable" rating.

    d. Proposed changes to the primary navigation (Nav Prime) displays on the OSO's Multi-Function Displays (MFD) were rated "Totally Acceptable." These changes were independent of the proposed ALT LAR changes.

    e. The Map Enable function increased OSO situational awareness.

    f. Track Handle control of the OSO's MFD was rated "Very Useful," however, further improvements to the ERS implementation are warranted.

    g. Implementation of OSO controlled steering commands to the pilot's station was insufficient to improve pilot situational awareness.

2.0 INTRODUCTION

Over the last several years the B-1B System Program Office Engineering Department (ASC/YDE) in conjunction with the Crew Station Evaluation Facility (CSEF) of the Engineering Directorate of Aeronautical Systems Center (ASC/ENFC) has conducted a series of applied human factors engineering studies. They have used the B-1B Engineering Research Simulator (ERS) as a major tool in these studies. Some examples of past efforts include Defensive System Upgrade Program (DSUP) studies, Conventional Mission Upgrade Program (CMUP) studies, Block Upgrade studies, Crew Station Working Group (CSWG) support, a Link 16 Study, and a Baseline Study (Kalman, Kline, Provost, Gable, & Taylor, 1999). Government engineers have worked closely with the contractors, Boeing (B-1B) and L3 Communications (formerly Raytheon Training Systems) (CSEF), to support these applied human factors engineering efforts and to help fold the results back into the B-1B system to make it a safer and more effective weapon system.

New smart weapons and advanced avionics systems have spurred the need for B-1B upgrades. The current Block D upgrade provides the B-1B the capability to carry 24 Joint Direct Attack Munitions (JDAMs). The JDAM tail kit turns a 2000-pound dumb bomb (a.k.a. MK-84) into a global positioning system (GPS) aided inertial navigation system (INS) guided near precision weapon. This increase in weapon capabilities also increases mission complexity. Before Block D, the B-1B would drop multiple bombs on a single target area. Now the B-1B has the capability to direct individual weapons to individual targets. Since a JDAM is a guided weapon, the weapon launch point has expanded into a region. The launch acceptability region (LAR) is the area from which the JDAM must be launched in order to achieve the desired mean point of impact (DMPI). The mission complexity arises when multiple DMPIs are planned resulting in multiple LARs. The proposed Block E upgrade incorporates advanced weapons delivery computers, terrain following computers, guidance/navigation computers, and controls/displays computers. These upgrades will be critical for crewmember situational awareness in the JDAM environment. The ALT LAR effort was based on the recommendations made in the B-1B Human Factors Baseline Study Report (Kalman, et al., 1999). This study indicated the need for improvements to the Block E LAR displays.

3.0 STUDY OBJECTIVE

The objective of this study was to perform a human factors evaluation of B-1B Alternative Launch Acceptability Region Displays and make recommendations to B-1B System Program Office Engineering (SPO) (ASC/YDE).

4.0 METHOD

4.1 Subjects

a. Five B-1B Crews – Pilot, Copilot, Offensive System Operator (OSO) and Defensive System Operator (DSO) (i.e., 20 total subjects) were scheduled. Due to conflicts, two of the five crews were only able to supply one pilot for the study. As a result, a total of ten Weapon System Operators (WSO) and eight pilots participated in the study.

b. ASC/YDE was responsible for supplying the subjects.

c. The crews were on station at the CSEF for approximately 1 day to participate in the ALT LAR study. Pilots and copilots stayed an additional day to participate in the Radar Warning Receiver (RWR) Display study.

4.2 B-1B ERS

The study was performed at Wright-Patterson AFB, Ohio, Area B, Building 145, Simulation Bay 2 and used the B-1B Engineering Research Simulator (ERS). No hardware changes to the B-1B ERS were necessary for this study.

4.3 Subject Training

Crews were given an introduction briefing covering the study's purpose, procedures, and schedule. Each crew was given B-1B ERS familiarization time to fly practice missions and/or a series of mission segments before data collection began. Data collection missions were briefed prior to flight.

4.4 Missions

There was one type of Data Collection mission (see figure 1). The Data Collection mission was based on the mission from the B-1B Human Factors Baseline Study (Kalman, et al., 1999). The mission was flown twice with the ALT LAR displays, with crewmembers changing seats between missions (e.g., DSO to OSO's seat). The mission contained threats, hung stores, and forced deviations from the "black line" or planned route. The mission objective was to navigate through 3 planned target areas that included 22 JDAM targets. The crews were instructed to use standard operating procedures for threat avoidance.

4.5 ALT LAR Displays

The primary displays for determining LAR location are found on the OSO's Multi-Function Display (MFD). The Target Summary display (E page) is the top-

level target format. The target summary display is made up of eight data fields. Fields one through seven are repeated for each target summary displayed. Field eight is repeated for each set of bay doors. Each field is defined as follows:

1. Event
2. Target Type
3. Target Bearing
4. Time-To-Go
5. Achievable Zone/Range
6. Range/Zone Status
7. Weapons Available/Required
8. Door/Position

The LAR Status Display (EB page) provides the OSO with a detailed status of each near-mode LAR target. The data for up to eight targets can be presented on one page. The shaded bar indicates the location and width of each target's in-zone LAR, relative to current aircraft parameters (see figure 2). The top and bottom lines represent the location and width for in-range LARs. An arrow on the left or right side indicates additional target data extends beyond the display area.

The ALT LAR displays contained the following features (see figures 2 and 3):

a. There was an improved EB page, which included:
    1. Angular representation of LAR bar in degrees
    2. Current Magnetic Heading
    3. Release Time-To-Go (TTG)
        i. When not heading towards LAR, times are estimated
        ii. When in LAR, TTG reads "LAR"
    4. Available Time in LAR (seconds)
        i. When in LAR, Time in LAR starts to count down
        (99 seconds is default maximum value for Time in LAR)
    5. OSO controlled mag-heading bug
        i. Can be connected to autopilot
        ii. Actual number drives bug, line is just a visual reference
    6. LARs show a "fly-into" orientation, the bottom LAR bar is the active weapon and successive weapons stack upward. (Current Block E has a top-down order of release.)
    7. Heading to DMPI
b. Estimated TTG was provided on E Page
c. OSO Track Handle control of LAR Bar Page functions (see figure 4)
    1. Declutter/Scale Field of View
    2. Heading Slew
    3. Page Scroll
    4. Heading Mode Enable/Disable
d. Map Enable function was incorporated (see figure 5)
    1. Located in OSOs upper right MFD
    2. Data included:
        i. Course line
        ii. Navigation points
        iii. DMPI location
        iv. LAR location

e. Offensive System Operator (OSO) controlled LAR Steering cue or bug (e.g., "chicken's foot") on pilot and copilot's Vertical Situation Display (VSD)

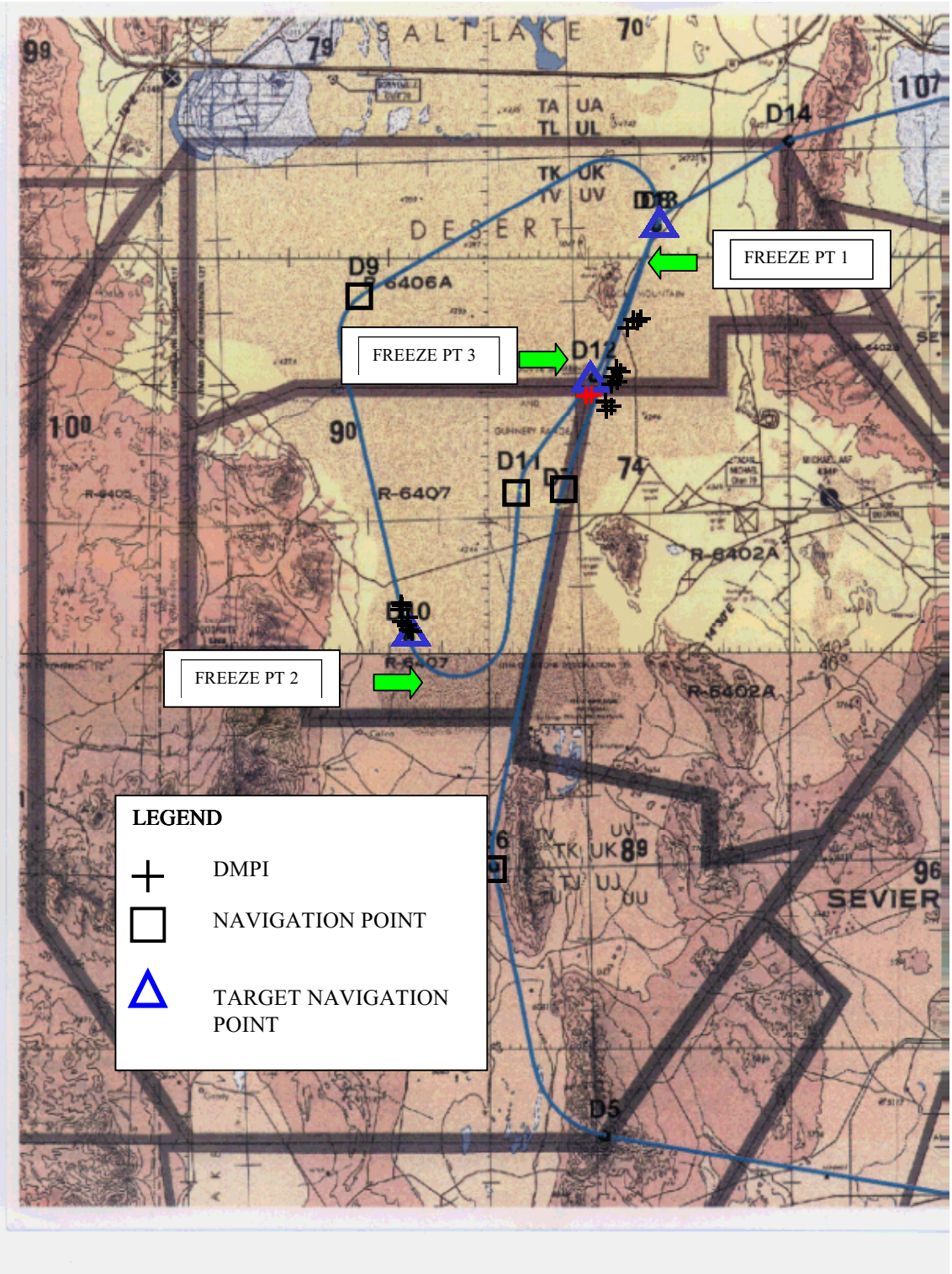

Figure 1. ALT LAR Mission

Angular representation of LAR Bar in degrees.

Current Mag Heading.

Time-To-Go/Time in LAR (sec) (Note: when not heading towards LAR, times are estimated). Default max value for time in LAR is 99 seconds.

OSO controlled mag-heading bug, can be coupled to autopilot. Actual number drives bug, line is just a visual reference.

LARs show a "fly-into" orientation, the bottom LAR is the first to drop.

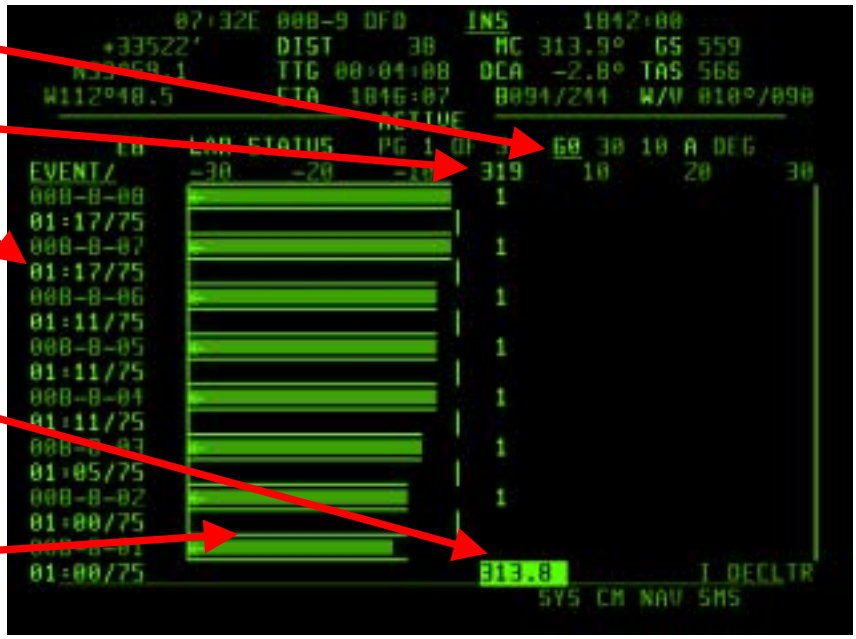

Figure 2. ALT LAR EB Page

D3 Mods

Replace Track (TK) with Magnetic Course (MC). Replace True Heading (TH) with the Digital Bullseye.

When in LAR TTG reads "LAR," and time in LAR starts to count down.

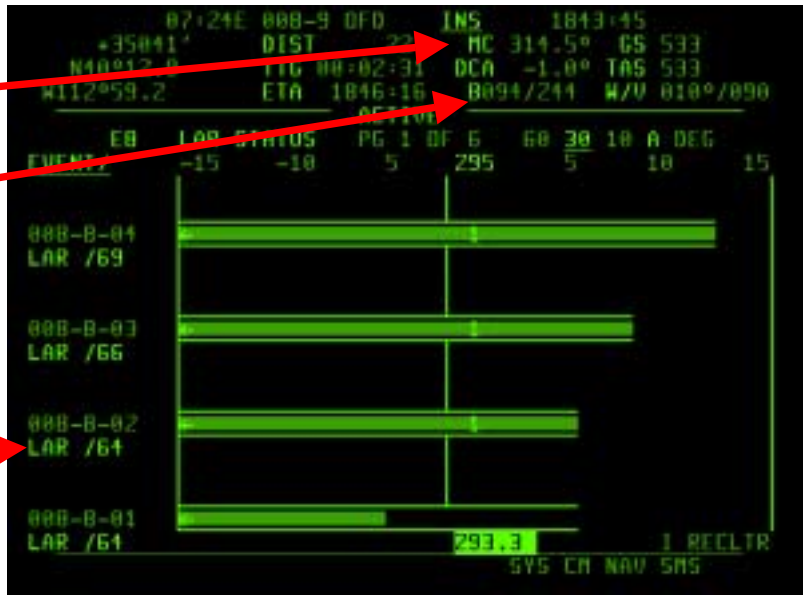

Figure 3. Decluttered ALT LAR EB Page

Track Handle Functions

1: Declutter/Scale Field of View
2: Heading Slew
3: Page Scroll
4: Heading Mode Enable/Disable

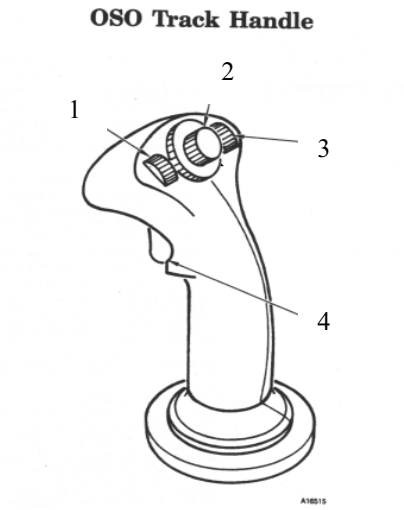

Figure 4. OSO Track Handle

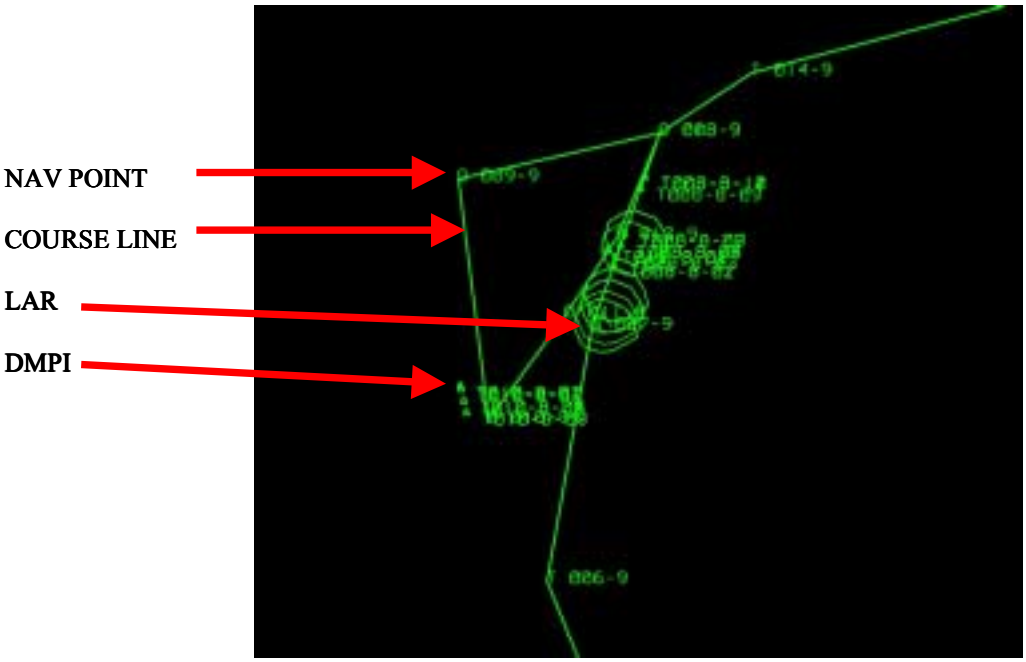

Figure 5. Map Enable Page

5.0 DATA COLLECTION

5.1 The following data were collected:

a. Workload - Subjective Workload Assessment Technique (SWAT)
b. Questionnaire - A questionnaire was given to obtain the WSO's subjective ratings and comments (See Appendix 1).
c. Video Tape - The OSO and Pilot were video taped during Data Collection missions
d. Number of bombs dropped within LAR
e. Duration and frequency of OSO utilization of the EB page and Map Enable on MFDs

5.2 SWAT data was collected during three pre-planned mission freeze points. The sole purpose for the freeze points was to collect SWAT data.

6.0 DATA ANALYSIS

6.1 Measures of Workload.

SWAT is used to assess mental workload by making relative comparisons of task conditions. SWAT is an accepted technique for determining if a task under one condition requires a greater mental workload than under another condition. SWAT was handled IAW "SUBJECTIVE WORKLOAD ASSESSMENT TECHNIQUE (SWAT): A USERS GUIDE (U)" AAMRL-TR-89-023, (Reid, Potter, & Bressler, July 1989). SWAT Version 3.1 was used to aid in the computer processing of the SWAT data. SWAT ratings are broken down into three parts: Time Load, Mental Effort Load, and Psychological Stress Load. During Training, the Crew accomplished the SWAT Card Sort. Only SWAT data was analyzed statistically by SPSS.

6.2 Questionnaires.

Questionnaire data is summarized by using average ratings and response frequency distributions (if appropriate) (See Appendix 1). Subject's comments are summarized.

6.3 There was no statistical comparison between B-1B Block E LAR and the ALT LAR SWAT scores.

The ALT LAR SWAT Scores were compared to the SWAT score of 40 which is regarded as the borderline score between acceptable workload (e.g., a score of 20) and unacceptable workload (e.g., a SWAT score of 50) (see figure 6).

6.4 All missions were video taped.

6.5 The number of bombs dropped within LAR was scored and analyzed (see table 1).

6.6 SWAT data analysis.

Figure 6 displays the mean SWAT values at each freeze point. At all freeze points SWAT exceeded the redline value of 40. As expected the highest workload was associated with freeze point 2 (67.53) and the least with freeze point 1 (52.01). However, there was no significant ($p>.05$) relationship between SWAT and freeze points. Likewise, adding OSO experience to the model again showed no significant differences (see Appendix 2). Given no significant main effects or interactions, further analysis was not warranted for SWAT.

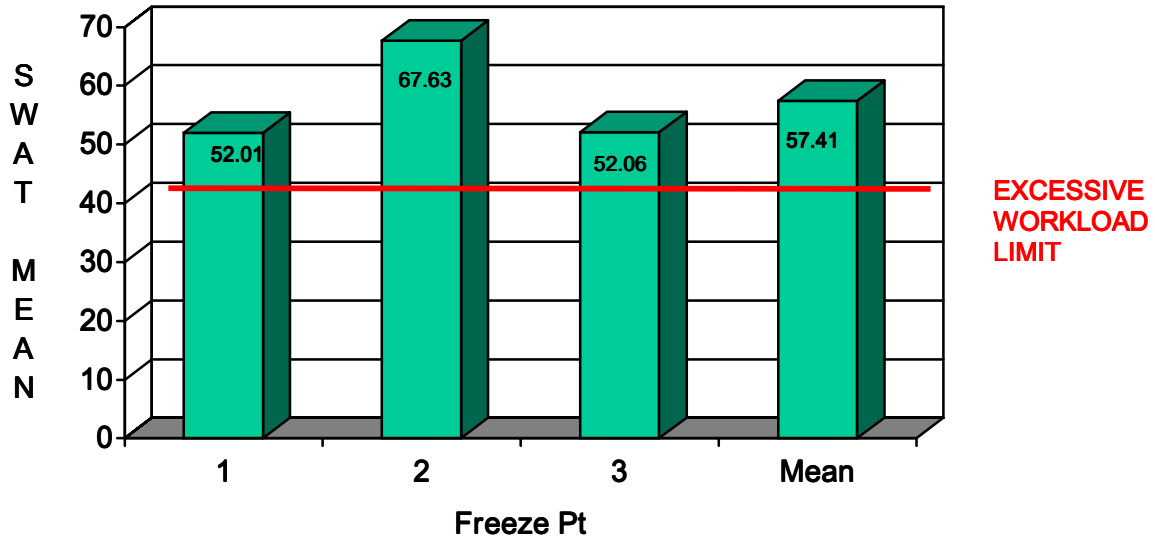

Figure 6. SWAT Ratings Compared to 40

6.7 Bombs on target.

The ALT LAR mission was pre-planned with 24 JDAM available. Of these, a total of 22 DMPI locations were assigned leaving 2 JDAM unassigned. During the first bomb run, a planned hung store occurred on an outer launcher location blocking two inner JDAM. As a result, a total of three JDAM were unusable leaving a total of 21 available JDAM. Due to JDAM variances in the bays, the automatic reallocation function was limited forcing the OSO to manually reallocate in order to achieve 100% mission success. The mission included a forced deviation from the planned route or "black line" due to threat avoidance. Table 1 depicts the bomb success rate per subject.

Table 1. Number of Bombs in LAR

CREW	JDAMS DROPPED	ON BLACK LINE	OFF BLACK LINE	MSN SUCCESS RATE IN %	NOTES
1	20	14 OF 15	6 OF 6	95.2	OSO elected not to reallocate hung weapons
2	19	14 OF 14	5 OF 7	90.5	Deviation from black line caused short time in LAR, OSO had good SA
3	18	12 OF 14	6 OF 7	85.7	Hung store task saturation, OSO slow to use available resources (i.e. EB page, Map Enable)
4	20	14 OF 14	6 OF 7	95.2	Slow to reallocate caused fly through LAR before all weapons released
5	21	14 OF 14	7 OF 7	100	
6	20	14 OF 15	6 OF 6	95.2	OSO elected not to reallocate hung weapons
7	21	14 OF 14	7 OF 7	100	
8	13	12 OF 14	1 OF 7	61.9	OSO lost SA during hung store reallocation and flew through LARs,
9	21	14 OF 14	7 OF 7	100	
10	21	14 OF 14	7 OF 7	100	
MEAN SUCCESS RATE		**95.77**	**85.29**	**92.4%**	

6.8 OSO utilization of EB page and Map Enable function (see table 3).

There was no correlation between SWAT and the two dependent measures of percent of time on the EB page and the percent of time on Map Enable (see Appendix 2). The two dependent measures, EB percent and Map Enable percent, were not significantly correlated ($p>.05$) with each other, requiring that they be analyzed in separate designs. As shown in figure 7, the time utilization percentages are fairly uniform for EB page. However, for Map Enable there is great disparity in percentage between freeze point one and the other freeze points. This is reflected in the separate repeated measures analysis. For both analyses, experience was kept in the model. Although the interaction of freeze point and experience was not significant ($p>.05$), keeping experience in the models raised the predictive value of the freeze point main effect (eta-square) from .237 to .411 for EB page and .412 to .750 for map enable. Even with experience in the model, there is no significance ($p>.05$) for the main effect of freeze point with EB page percentage as the dependent variable. As in the case of SWAT, further analysis was not warranted. On the other hand, significance

was found (p<.05) when the dependent variable was map enable percentage as displayed in table 2.

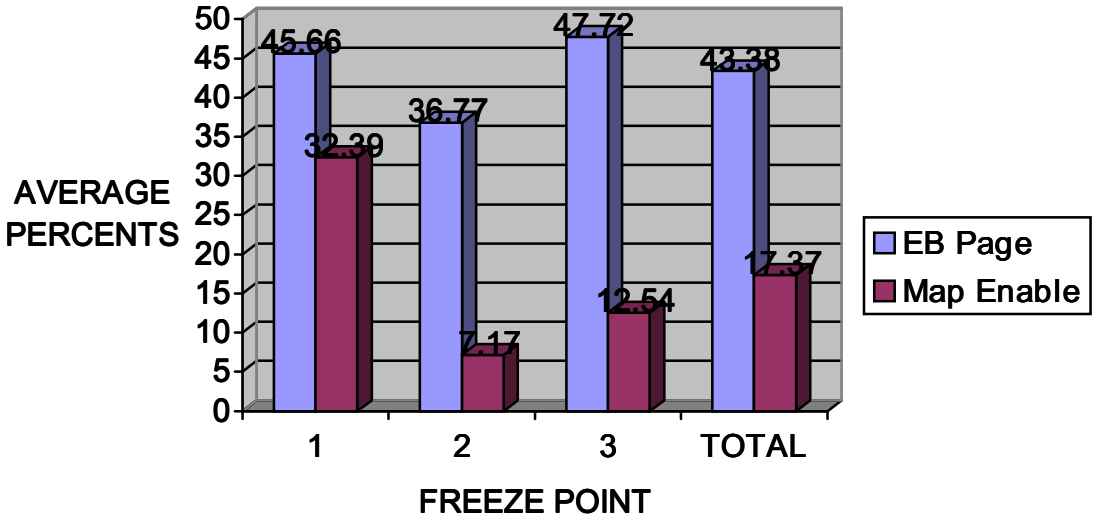

Figure 7. Average Utilization of EB Page and Map Enable

Table 2. Multivariate Effect of Freeze Point with Experience on Map Enable Percent of Time

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
FRZ_PT	Pillai's Trace	.750	7.505(a)	2.000	5.000	*.031	.750
	Wilks' Lambda	.250	7.505(a)	2.000	5.000	.031	.750
	Hotelling's Trace	3.002	7.505(a)	2.000	5.000	.031	.750
	Roy's Largest Root	3.002	7.505(a)	2.000	5.000	.031	.750
FRZ_PT * EXPERBIN	Pillai's Trace	.748	1.194	6.000	12.000	.372	.374
	Wilks' Lambda	.256	1.628(a)	6.000	10.000	.236	.494
	Hotelling's Trace	2.893	1.929	6.000	8.000	.191	.591
	Roy's Largest Root	2.889	5.777(b)	3.000	6.000	.033	.743
a Exact statistic							
b The statistic is an upper bound on F that yields a lower bound on the significance level.							
c Design: Intercept+EXPERBIN Within Subjects Design: FRZ_PT						*p<.05	

Table 3. OSO Utilization of "EB Page" and Map Enable

CREW	BOMB RUN	TIME ON EB PAGE (SEC)	% TIME ON EB PAGE	TIME ON MAP ENABLE (SEC)	% TIME ON MAP ENABLE
1	1	155	16.4	217	22.9
	2	121	21.5	32	5.7
	3	103	39.9	3	1.2
2	1	242	25.6	61	6.5
	2	220	39.0	68	12.1
	3	136	52.7	32	12.4
3	1	392	41.4	141	14.9
	2	101	17.9	0	0
	3	98	38.0	2	0.8
4	1	304	32.1	770	81.4
	2	40	7.1	0	0
	3	30	11.6	0	0
5	1	428	45.2	826	87.3
	2	199	35.3	2	0.4
	3	119	86.2	0	0
6	1	600	63.4	370	39.1
	2	481	85.3	60	10.6
	3	145	56.2	123	47.7
7	1	561	59.3	156	16.5
	2	111	19.7	19	3.4
	3	49	19.0	10	3.9
8	1	295	31.2	39	4.1
	2	112	19.9	70	12.4
	3	258	100.0	109	42.3
9	1	787	83.2	475	50.2
	2	356	63.1	58	10.3
	3	103	39.9	44	17.1
10	1	556	58.8	9	1.0
	2	332	58.9	95	16.8
	3	87	33.7	0	0
AVERAGE SCORES PER RUN	1	432 sec	45.66%	306.4 sec	32.39%
	2	207.3 sec	36.77%	40.4 sec	7.17%
	3	112.8 sec	47.722%	32.3 sec	12.54%

6.9 Questionnaire data analysis (see Appendix 1)

All study participants were asked to fill out a questionnaire after completing the study missions. All questionnaires contained demographic information followed by a pilot only, or WSO only, section.

All rating scales were:

7 Totally Acceptable
6 Very Acceptable
5 Somewhat Acceptable
4 Borderline
3 Somewhat Unacceptable
2 Very Unacceptable
1 Totally Unacceptable

All question ratings were averaged across crewmembers. This number determined the final rating. A rating frequency histogram is in Appendix 1 with each question.

All crew comments are reported in Appendix 1 verbatim.

7.0 DISCUSSION

7.1 SWAT discussion.

The B-1B ERS is a real time, high fidelity system, however, realistic combat mission conditions are not feasible for the study. For example, there is no visual system, which greatly reduces pilot procedures, and there is no aircraft communication with external agencies (e.g., AWACS, Command Post). In order to achieve a valid experimental design, OSO workload was artificially raised through the use of a pre-planned hung store during the first bomb run and forced deviations from the "black line" due to threat avoidance. The SWAT data was collected at three pre-determined freeze points throughout the mission in order to validate the OSO workload designed into the study. The Air Force Research Laboratory (the SWAT developer) has determined that a group mean score of 40 represents a "red line" (i.e., it is an indicator that performance may start to degrade). As the SWAT data shows, the OSO workload for the mission was over the "red line" for each mission segment with freeze point two showing the highest average score of 67.63. Since the manual reallocation of weapons occurred mostly between freeze points one and two, the highest SWAT scores were expected for this mission segment.

Further analysis shows that there was no correlation between OSO experience and workload levels. Consequently, workload was determined to be high for the planned mission for all OSOs. It is important to understand that high workload is an intended effect. In a low workload environment, we would expect a very high mission success rate. In a high workload environment we expect OSO performance to deteriorate. The OSOs were placed into an artificially high workload environment in order evaluate performance under these simulated conditions.

7.2 OSO performance.

In a high workload environment, the OSOs were able to average a bombs-on-target rate or mission success rate of 92.4%. A total of four crews achieved a 100% success rate and only two crews scored below 90%. These statistics provide a favorable objective measure of the ALT LAR software. When workload is increased, the OSO only experienced a 7.6% average degradation in performance. Breaking down bombing statistics with respect to deviations from the pre-planned route or "black line," the results show 95.77% accuracy when on the "black line" and 85.77% when off the "black line." Experiencing only a 10% decrease in performance when major deviations occurred from planned route is another favorable objective measure supporting the ALT LAR displays. Also, a review of the mission tapes shows that several OSOs maintained situational awareness and realized that they were going to exit LAR before all weapons were released due to launcher rotation limitations.

As a subjective measure, the questionnaires also show strong support for the ALT LAR information. The ALT LAR changes to current block E displays were rated

"very acceptable" scoring 6.2 on a scale of 1 to 7. Each individual modification was also rated for its acceptability. The modifications receiving a "very acceptable" rating (5.6 to 6.5) include: heading mode to provide steering commands, LAR bar display, implementation of the track handle, declutter mode, all scale modes of the LAR bar display, time-to-go/time-in-LAR information on the EB page, angular representation of LAR bar page, and magnetic heading information on the LAR bar page.

The OSOs also rated the operational utility of the ALT LAR displays. Ability to line up multiple LARs and target situational awareness (both on and off black line) received a "very acceptable" rating. Inter-crew coordination only received a somewhat acceptable rating.

Analysis of the OSO utilization of the EB page also shows favorable support for the ALT LAR changes. There was a 43.38% average utilization rate per bomb run of the EB page. However, since the EB page is primarily designed as a target guidance system, this actually constitutes a 151% of the pre-planned IP-to-target mission segment times. Observation of the mission tapes shows that most OSOs elected an early sequence to the target waypoint in order to gain full functionality of the EB page.

The track handle implementation received strong support. However, as implemented in the ERS, there was some concern over the heading mode functionality. When in heading mode, there was no indication at the pilot's station that heading mode was selected. Also, a conscious effort on the OSO's part was required to deselect heading mode when no longer needed. This resulted in deviations from planned route of flight on several occasions.

7.3 Other OSO modifications.

This study incorporated two modifications separate from the ALT LAR changes. The first modification was the implementation of the Map Enable function (see figure 5). This function allowed the OSO a "God's eye view" of the mission. Typical OSO comments on the Map Enable function were very positive (see Appendix 2):

- (Map Enable mode) is a huge SA builder
- Map Enable really helps with deviation. Without it, it would be more difficult to keep SA
- Map is great with LARs
- The Map does wonders after getting distracted…

One area of concern is derived from analysis of the utilization rates of the Map Enable function. There is a significant correlation between high workload and low utilization of the Map Enable feature when analyzed across experience levels. This finding suggests that placing the function on one of the two MFDs may not be an optimum solution. The OSOs use the MFDs for navigation, target

information, and weapon monitoring during the bombing run. Although the Map Enable feature positively influences situational awareness, it restricts use of as much as 50% of available MFD information.

The second modification incorporated changes to the Nav Prime displays on the top of the MFDs (see figure 3). The change replaced True Track and True Heading information with Magnetic Course and Digital Bullseye information. The questionnaire data rated these changes as "Totally Acceptable" (see Appendix 1).

7.4 Pilot questionnaires.

The only modification to the pilots station for this study was the implementation of the heading cursor or "chicken foot." This modification allowed the OSO to give steering commands through his MFD to the pilot. According to questionnaires, the pilots rated targeting information as "Somewhat Unacceptable" (See Appendix 1). The two other factors analyzed, target situational awareness (both on and off "black line") and inter-crew coordination, were also rated as "Somewhat Unacceptable." Most comments indicated the need for more information:

- After a threat reaction, dismal SA becomes abysmal
- Pilots have almost no SA after deviations
- Situational awareness inputs are less than optimum because they rely on verbal inputs from the OSO rather than a visual presentation

8.0 RECOMMENDATIONS

8.1 ALT LAR recommendations.
Control and display improvements to the current Block E LAR displays are recommended to increase the OSO's situational awareness and improve performance.

a. Time-to-go and time-in-LAR information should be incorporated into the EB page. This change will greatly reduce cycling between MFD pages.

b. A scalable angular representation of the LAR bars with a fly-through orientation (bottom-to-top) should be incorporated. This will improve OSO situational awareness by showing relative distance to the LARs.

c. Estimated time-to-go information needs to be included when in near-mode ranging and not heading towards LAR. Technical Manual information should note that this information may be inaccurate but will update real time as the aircraft heading approaches LAR intercept heading.

d. Current aircraft magnetic heading should be included on EB page.

e. Track Handle control of EB page functions would improve OSO performance. Further analysis of the heading mode function and "chicken foot" control is warranted.

8.2 Other OSO modifications.

a. The Map Enable function or similar format should be incorporated into the OSO station. This improvement will greatly increase OSO situational awareness. Serious consideration should be given to finding an alternate location than on one of the two MFDs.

b. Changes to the Nav Prime displays should be implemented. This modification had the strongest support from the OSOs in the study.

8.3 Pilot station recommendations.
ilot situational awareness in terms of LAR is unacceptable. Current displays should be improved to include LAR information and current track line.

APPENDIX 1. QUESTIONNAIRES

B-1B

Alternative Launch Acceptability Region (ALT LAR) Study Questionnaire

1. **A. Pilot/Copilot Experience**

Current Qualified Aircraft: _____ Number of Flying Hrs_____

B-1B Flight Hours: Average: 1340 Min: 260 Max: 2300

Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____

Total Flying Hrs: _____

1. **Total Flight Hours: Average: 2086 Min: 470 Max: 3600**

2. **Have you had previous B-1B Block D?** Yes 7 No 1

If yes, what aircraft/simulator(s)? **Sim-1, A/C-6** Number of Hrs **Ave: 79 Min: 10 Max: 200**

3. **Have you had any training on JDAM?** Yes 7 No 1

4. **Are you familiar with Launch Acceptability Regions (LARs)?** Yes 7 No 1

5. **Have you ever participated in any B-1B studies or flight tests?** Yes 5 No 3

If yes, describe: ALR-56M Repeater, ERS Baseline, Block D IOT&E, Block D FDE, PT EPW, OT&E, TD&E, FME, ILS display, VSD upgrade.

Pilot Section:

1. Rate the acceptability of the **LAR heading display (chicken foot) and targeting information.** Use the following scale:

	Ratings:
7 Totally Acceptable	**0**
6 Very Acceptable	**0**
5 Somewhat Acceptable	**0**
4 Borderline	**3**
3 Somewhat Unacceptable	**2**
2 Very Unacceptable	**1**
1 Totally Unacceptable	**2**

RATING: _____ **Average: 3.38**

Comments:

- I need to have LAR displays up-front.
- Pilots need display of LAR - moving map with threat and LAR display would be great!!
- Need message on VSD indicating OSO is steering the LAR, i.e., "LAR STRG."
- Need some way to let pilots know which steering mode the OSO is in. Recommend CDI stay connected to Nav point and just heading bug move.
- Steering commands are fine, however the LAR heading display alone does not provide sufficient situational awareness to allow the pilot to place the aircraft in the LAR.
- Targeting information is only available at pilot station if the pilots program each DMPI into the CDU, but this is only info to go DMPI direct. The info from the CDU does not indicate heading to LAR entry center lead point.
- The chickenfoot was fine, however, targeting information was also adequate.

2. Were you able to use the LAR Heading Display to **steer** to the upcoming weapons LAR(s)?

Yes 7 No 1 Comments:

- Need some indicator/reverse video up-front for when OSO goes into LAR steering
- Chickenfoot and voice directions are insufficient in a task saturation and comm. Intensive environment.
- There is no LAR steering in the front station
- Pilots need some type of "God's Eye" view with LAR superimposed.
- The pilot can manually turn beyond 30° bank to reach the LAR with positive SA only when prompted by the OSO after the OSO selected heading mode.
- Easily

3. Rate the acceptability of the overall **Target Situational Awareness.** Use the following scale:

	Ratings:
7 Totally Acceptable	**0**
6 Very Acceptable	**1**
5 Somewhat Acceptable	**2**
4 Borderline	**2**
3 Somewhat Unacceptable	**3**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 3.50**

Comments:

- I need to know where the LARs are at in relation to me and the target! I need to be able to back up WSOs without having to garbage up the intercom.
- Pilots need better early-late indication; perhaps a digital readout of exact timing like WSO stations.
- Have no target situational awareness.
- Pilots need some type of "God's Eye" view with LAR superimposed.
- Situational awareness inputs are less than optimum because they rely on verbal inputs from the OSO rather than a visual presentation. The best target situational awareness would include a dynamic LAR display with LAR entry/exit countdown displays.
- The OSO has a LAR display with current trackline, so he must vocalize time-to-LAR and turn direction. In a communications/threat intensive environment, this will be difficult without a repeater scope at the pilot station displaying both time-to-LAR and LAR position/direction. The pilot station needs a visual indicator to build SA to LAR.
- I thought target SA would be good.

4. Rate the acceptability of the **Target Situational Awareness** with respect to deviations from the planned route. Use the following scale:

	Ratings:
7 Totally Acceptable	**0**
6 Very Acceptable	**1**
5 Somewhat Acceptable	**2**
4 Borderline	**0**
3 Somewhat Unacceptable	**1**
2 Very Unacceptable	**2**
1 Totally Unacceptable	**2**

RATING: _____ **Average: 3.13**

Comments:

- After a threat reaction, dismal SA becomes abysmal. I need to know where the LARs are at in relation to me and the target! I need to be able to back up WSOs without having to garbage up the intercom.
- Pilots have almost no SA after deviations. We need to independently steer to a displayed LAR.
- No target displays.
- Pilots need some type of "God's Eye" view with LAR superimposed.
- Situational awareness inputs are less than optimum because they rely on verbal inputs from the OSO rather than a visual presentation. The best target situational awareness would include a dynamic LAR display with LAR entry/exit countdown displays. This setup requires verbal description from the OSO. Visual presentation would be far more efficient
- Targeting information is only available at pilot station if the pilots program each DMPI into the CDU, but this is only info to go DMPI direct. The info from the CDU does not indicate heading to LAR entry center lead point.
- The OSO has a LAR display with current trackline, so he must vocalize time-to-LAR and turn direction. In a comm/threat intensive environment, this will be difficult without a repeater scope at the pilot station displaying both time-to-LAR and LAR position/direction. The pilot station needs a visual indicator to build SA to LAR.
- If the IP is near/after the LAR, and IP D# is flown to, the pilot has absolutely no SA that he has passed the LAR while thinking he is flying IP to target D#.
- Still very good.

5. Rate the acceptability of the **Inter-Crew Coordination** with respect to LAR navigation. Use the following scale:

	Ratings:
7 Totally Acceptable	**0**
6 Very Acceptable	**0**
5 Somewhat Acceptable	**3**
4 Borderline	**2**
3 Somewhat Unacceptable	**1**
2 Very Unacceptable	**1**
1 Totally Unacceptable	**1**

RATING: _____ **Average: 3.36**

Comments:

- Doing a bomb run must not be this comm intensive. We need to give everyone in the jet as much SA as possible instead of designing a "I've got a secret" cockpit setup.
- Comm breaks down in a comm intensive or high task environment. Need a birdseye view of LAR at front station.
- Pilots need to have an indication of when the OSO has taken control of heading marker/chickenfoot (reverse video)
- Need message on VSD indicating OSO is steering the LAR, i.e. "LAR STRG"
- Pilots must know the type of steering the WSO has.
- Situational awareness inputs are less than optimum because they rely on verbal inputs from the OSO rather than a visual presentation. The best target situational awareness would include a dynamic LAR display with LAR entry/exit countdown displays. This setup requires verbal description from the OSO. Visual presentation would be far more efficient.
- Targeting information is only available at pilot station if the pilots program each DMPI into the CDU, but this is only info to go DMPI direct. The info from the CDU does not indicate heading to LAR entry center lead point.
- The OSO has a LAR display with current trackline, so he must vocalize time-to-LAR and turn direction. In a comm/threat intensive environment, this will be difficult without a repeater scope at the pilot station displaying both time-to-LAR and LAR position/direction. The pilot station needs a visual indicator to build SA to LAR.
- In an comm/threat intensive environment the OSO must verbalize the SA off of his scope, while the integration of CDU DMPI direct information does not allow for maximum threat avoidance, while still obtaining LAR, due to having to point the nose directly at the DMPI which might mean entering a threat WEZ.
- Very good.

General Comments:

- Dynamic DOB - even if a threat quits emitting, need to have some sort of "save" function so we continue to have SA on a threat that did emit, but no longer is.
- Bullseye readout of whatever the OSO locks up on radar - like a tanker.
- DSO compass rose need the 30° increments on it - N, 030, 060, E, 120 etc.
- Investigation of the bank release angle limitation while releasing JDAMs, if we can safely release in 10, 20, or 30° bank, why not pull restriction from T.O. IF you must be in 0° bank, limit LAR Heading Display "chicken-foot" updates to outside 5 sec. from LAR like is done during GMTI bombing.
- ILST - need repeater at pilot-station - need bullseye readout of radar contacts.
- Compatible NVG lighting.
- Moving map with course, LAR, threat (at least DOB) overlay.

OSO Section

B. WSO Experience

Current Qualified Aircraft: _____Number of Flying Hrs_____

B-1B DSO Hrs: **Ave: 604, Min: 100, Max: 1200** A/C Block: **A-D**

B-1B OSO Hrs **Ave: 714, Min: 100, Max: 1600** A/C Block: **A-D**

Other Aircraft Flown:_____Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____
Other Aircraft Flown: _____ Number of Flying Hrs_____

Total Flying Hrs: Ave: 1992, Min: 350, Max: 3600

1. **Have you had previous B-1B Block D?** Yes 6 No 4

   If yes, what aircraft/simulator(s)? **A/C: 5**, Number of Hrs **Ave: 150 Min: 20 Max: 300**

2. **Have you had any training on JDAM?** Yes 9 No 1

3. **Are you familiar with Launch Acceptability Regions (LARs)?** Yes 10 No 0

4. **Have you ever participated in any B-1B studies or flight tests?** Yes 3 No 7

   If yes, describe: **Human Factors studies, Block D flight test, Baseline, Block E/F and D**

1. Rate the acceptability of the **LAR displays and targeting information**. Use the following scale:

	Ratings:
7 Totally Acceptable	**1**
6 Very Acceptable	**7**
5 Somewhat Acceptable	**2**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 5.90**

Comments:

- During bomb runs I had to cycle through E, EB and D pages. Switching pages lowered my SA.
- No Block D experience. LAR bars with steering from OSO are somewhat useful, but pilots don't know what is driving "chicken foot" - steering command from OSO or DAS & steer #.
- The [EB] LAR bars are great - especially when WSO/OSO has familiarization time with formats.
- Very good compared to Block D - much more situational awareness available.
- The [EB] page is very helpful and SA building. In general data on the MFD displays go from top-to-bottom. This data goes from bottom to top. It is different, but I believe the WSO can adjust.
- The pylon function is a huge SA builder.
- What range is the "God's eye" view? Great SA however! Far [mode] ranging information is good.
- I would suggest taking out the -8 (representing the target.) It is unnecessary because we knew it is a target.

2. Are you familiar with current **Block E LAR displays**?

Yes **5** No **5**

2 a.) If yes, rate the operational utility of the **ALT LAR** changes to the current Block E displays. Use the following scale.

	Ratings:
7 Totally Acceptable	**2**
6 Very Acceptable	**2**
5 Somewhat Acceptable	**1**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 6.20**

Comments:

- Again, become more familiar with new EA and EB and DAC formats - the LAR display is superb.
- The ALT LAR display [EB] should go from top-to-bottom v. bottom-to-top. All data is currently read top-to-bottom on all our MFB pages.
- Need to put ENBL/ALL or EA page to greatly minimize hey strokes especially in a re-allocation situation.
- Need to use something besides "NONE" for a non-allocated weapon use "AVLB" for available.

3. Rate the acceptability of the **Heading Mode** for providing **steering commands** for upcoming weapons LAR(s) to the pilot. Use the following scale:

	Ratings:
7 Totally Acceptable	**1**
6 Very Acceptable	**5**
5 Somewhat Acceptable	**3**
4 Borderline	**1**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 5.60**

Comments:

- For black-line sorties it is acceptable. However, during threat reaction, it is unacceptable. The E page provides more SA since it provides degrees L or R.
- LAR bars with steering from OSO are somewhat useful, but pilots don't know what is driving "chicken foot" - steering command from OSO or DAS & steer #. Give pilots an indication on VSD as to which mode the OSO is in.
- Good option from at least 4 minutes out from LAR release.
- WSO/OSO need to remember to go to pilot nav. heading!
- It is good except there isn't any indication to the crew that this is engaged. Need some kind of indication to the pilots (at least that heading mode is engaged.)
- This is a very nice option. I like being able to give steering commands to the LAR.
- Given the extra SA available to the OSO, this function could provide immediate access to aircraft heading control. Could improve reaction time with the proper use of CRM, i.e. inform pilot if the OSO is changing A/C attitude. (I like this feature.)
- Good heading mode capability, but a critical flight coordination item! Has to be a way for pilot to disengage the heading mode.
- Even with heading mode engaged it would be convenient for the system to sequence with all weapons out and past target.

4. Rate the operational utility of the **LAR display** for lining up multiple LARs. Use the following scale:

	Ratings:
7 Totally Acceptable	**2**
6 Very Acceptable	**7**
5 Somewhat Acceptable	**1**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 6.10**

Comments:

- Very useful, especially for vertically constrained targets.
- Good/excellent display for multiple release, yet due to MFD only 8 are displayed whenever your target is 8 or more JDAM.
- Overall superb!
- Much better than what is available in Block D.
- Other than time to LAR - a graphic presentation for LAR separation (TTG) would be good.
- In the event of multiple LARs, the pylon function rapidly decreases in utility. This LAR display becomes very important for SA construction.
- Much better than Block-D displays especially with arrows with a heading to come to. Once in near ranging especially in middle of re-allocation or off track for maneuvering can be difficult.

5. Were you able to follow the **sequence of weapons releases** using the LAR Display?

Yes **10** No **0** Comments:

- WSO needs to get used to bottom-up display.
- Very Good!
- Bottom-to-top is good on sequence of release.
- However, I had a tendency to start at the top of the [EB] versus the bottom.
- But, very difficult to follow during a multiple ripple.
- Fairly well.
- Great job on time-to-exit LAR

6. Rate the acceptability of the **Inter-Crew Coordination**. Use the following scale:

	Ratings:
7 Totally Acceptable	**0**
6 Very Acceptable	**3**
5 Somewhat Acceptable	**7**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 5.30**

Comments:

- With practice it would improve.
- More comm was needed to maneuver AC to LAR. Having not flown Block D, no technique for MAN/Auto launch and platform navigation and time control seems to be deferred to DSO with weapons faults.
- Due to ERS limitation between pilots and WSOs it worked ok!
- Procedures will be developed (techniques as well).
- Pilots still [need] their own LAR SA.
- Remember heading mode disengagement is critical for crew coordination in threat area.

7. Rate the acceptability of the overall **Target Situational Awareness**. Use the following scale:

	Ratings:
7 Totally Acceptable	**2**
6 Very Acceptable	**5**
5 Somewhat Acceptable	**3**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 5.90**

Comments:

- For "black-line" runs [EB] page was helpful.
- SA can be lost reallocating weapons if system doesn't do it. The map (pylon sw) does wonders after getting distracted updating weapons. A few seconds and SA is back.
- Gave us the "big picture."
- Ability to select different ranges on map enable.
- Map enable is a very good tool for helping out in target SA - would like to have different ranges available.
- Map enable is a must. It was nice to see the dynamic bi-ellipses.
- Somewhat confusing when re-allocations occur.
- Once you get used to it, actually gives great information!
- Bullseye information great! Also altitude readout is good.
- Using the pylon switch to bring up the map increases target SA.

8. Rate the acceptability of the **Target Situational Awareness** with respect to deviations from the planned route. Use the following scale:

	Ratings:
7 Totally Acceptable	1
6 Very Acceptable	6
5 Somewhat Acceptable	2
4 Borderline	1
3 Somewhat Unacceptable	
2 Very Unacceptable	
1 Totally Unacceptable	

RATING: _____ **Average: 5.70**

Comments:

- The [E] page provides more SA for me since there is a degrees L/R display. Maybe with practice, the [EB] page will be feasible.
- Map is great with LARs. Understanding LARs on EB page and how turning affects page is a must.
- Overall super - especially with map enable.
- Map enable really helps with deviation. Without it, it would be more difficult to keep S.A.
- This is acceptable because of map enable feature.
- Once again the pylon mode was useful.
- LAR displays with deviations is hard when not in Near mode ranging especially if close to DMPIs.
- Moving LAR on map is a little confusing at first. Would not be a problem with practice

9. Rate the implementation of the **Track Handle**. Use the following scale:

	Ratings:
7 Totally Acceptable	**3**
6 Very Acceptable	**4**
5 Somewhat Acceptable	**3**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 6.00**

Comments:

- During threat reactions, or moving from one page to another de-selecting steering command is easy to drop out of crosscheck.
- Pilots need indication of what heading mode OSO is in.
- We reviewed and worked the "LAR" option of the track handle. The ILST with track handle options may add more stress/workload for WSOs.
- Track handle function is great. Add.
- A more visible reminder when the track handle has heading.

10. Rate the operational utility of the **Declutter Mode**. Use the following scale:

	Ratings:
7 Totally Acceptable	**3**
6 Very Acceptable	**5**
5 Somewhat Acceptable	**1**
4 Borderline	**1**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 6.00**

Comments:

- If 4 or less targets, much easier to read screen.
- Superb!! Keep it!
- Good in that it lets you concentrate on just 4 of the releases (if desired).
- Only necessary when accomplishing a multiple release of 10 or more.
- Did not have a chance to try this.
- Declutter helps to not get too much info.

11. Rate the acceptability of the **scale modes**. Use the following scales:

a). 60°

	Ratings:
7 Totally Acceptable	4
6 Very Acceptable	3
5 Somewhat Acceptable	3
4 Borderline	0
3 Somewhat Unacceptable	0
2 Very Unacceptable	0
1 Totally Unacceptable	0
	Average: 6.10

b). 30°

	Ratings:
7 Totally Acceptable	4
6 Very Acceptable	3
5 Somewhat Acceptable	3
4 Borderline	0
3 Somewhat Unacceptable	0
2 Very Unacceptable	0
1 Totally Unacceptable	0
	Average: 6.10

c). 10°

	Ratings:
7 Totally Acceptable	4
6 Very Acceptable	1
5 Somewhat Acceptable	4
4 Borderline	1
3 Somewhat Unacceptable	0
2 Very Unacceptable	0
1 Totally Unacceptable	0
	Average: 5.80

Comments:

- I did not use the 30° or 10° due to task saturation and limits on range size.
- Keep it!!
- Did not use this. Seems conceptually useful.
- Did not utilize this function much.

12. Rate the operational utility of the **Time-to-go/Time-in-LAR** information on the EB page. Use the following scale:

	Ratings:
7 Totally Acceptable	**4**
6 Very Acceptable	**6**
5 Somewhat Acceptable	**0**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 6.40**

Comments:

- TTG/Time in LAR used in combination with map is good.
- Keep it! After WSO gets used to the formats - information offers same data as Block D [I] page.
- Very useful information except the Time-In-LAR information was based on "best case" intercept across farthest points. If you are just inside the left edge of the LAR you will transit the LAR much quicker.
- I like it!

13. On the EB page, which drop order do you prefer?

Top-to-bottom _3_

Bottom-to-top _7_

Comments:

- Top-to-Bottom doesn't make any sense.
- It's fine/OK
- As you fly into the LAR!

14. Rate the operational utility of the **angular representation** on the **LAR bar.** Use the following scale:

	Ratings:
7 Totally Acceptable	**3**
6 Very Acceptable	**2**
5 Somewhat Acceptable	**5**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 5.80**

Comments:

- Represents in relation to distance. Keep it!
- OK, but when in Near ranging with no azimuth constraint I am looking to put or line up (center) the A/C in the heart of the LAR.

15. Rate the operational utility of the **Magnetic Heading** information on the EB page. Use the following scale:

	Ratings:
7 Totally Acceptable	**3**
6 Very Acceptable	**5**
5 Somewhat Acceptable	**2**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	**0**

RATING: _____ **Average: 6.10**

Comments:

Nice, but most people use HSI. Keep it / Superb! Old dog - still need to break away from GNAV summary. During HDG MODE, heading useful. When in HDG mode need to know what heading A/C is presently on.

16. Rate the operational utility of the **Digital Bull and Magnetic Course** information on the Nav Prime Display. Use the following scale:

	Ratings:
7 Totally Acceptable	**9**
6 Very Acceptable	**1**
5 Somewhat Acceptable	**0**
4 Borderline	**0**
3 Somewhat Unacceptable	**0**
2 Very Unacceptable	**0**
1 Totally Unacceptable	0

RATING: _____ **Average: 6.90**

Comments:

- Digital Bull in the B-1 a must!
- Bull is a must. Multiple Bulls and ability to change it is needed also.
- Definitely keep it!
- This provides massive amounts of SA.
- We need this feature now!!
- This is huge. The B-1B has a hard time maintaining SA during an air-to-air merge. This information is a source of instant Bull location of A/C. The Bull information on the DSO scope is also huge. Wish we had it coming too. Gives us threat bull info as well..
- Both great!

General Comments:

- Without Block D experience.
- Eye opening from perspective of having heard some of office critiques of Block D. ALT LAR is straightforward with experience and understanding of how turns effect LAR. Graphical map does wonders for SA. Block F DAS is nice with compass rose and bull.

APPENDIX 2. STATISTICS TABLES

Table 4. Correlations Among Variables

		freeze pt	SWAT	EBPCT	MAPPCT
freeze pt	Pearson Correlation	1.000	.009	.035	-.354
	Sig. (2-tailed)	.	.962	.852	.055
	N	30	30	30	30
SWAT	Pearson Correlation	.009	1.000	-.062	.069
	Sig. (2-tailed)	.962	.	.744	.719
	N	30	30	30	30
EBPCT	Pearson Correlation	.035	-.062	1.000	.295
	Sig. (2-tailed)	.852	.744	.	.114
	N	30	30	30	30
MAPPCT	Pearson Correlation	-.354	.069	.295	1.000
	Sig. (2-tailed)	.055	.719	.114	.
	N	30	30	30	30

Table 5. Multivariate Effect of Freeze Point on SWAT

Effect		Value	F	Hypothesis df	Error df	Sig.
Freeze Point	Pillai's Trace	.385	2.507(a)	2.000	8.000	.143
	Wilks' Lambda	.615	2.507(a)	2.000	8.000	.143
	Hotelling's Trace	.627	2.507(a)	2.000	8.000	.143
	Roy's Largest Root	.627	2.507(a)	2.000	8.000	.143
a Exact statistic						
b Design: Intercept Within Subjects Design: FRZ_PT						

Table 6. Multivariate Effect of Freeze Point and Experience on SWAT

Effect		Value	F	Hypothesis df	Error df	Sig.
Freeze Point	Pillai's Trace	.476	2.273(a)	2.000	5.000	.199
	Wilks' Lambda	.524	2.273(a)	2.000	5.000	.199
	Hotelling's Trace	.909	2.273(a)	2.000	5.000	.199
	Roy's Largest Root	.909	2.273(a)	2.000	5.000	.199
FRZ_PT * EXPERBIN	Pillai's Trace	.268	.309	6.000	12.000	.920
	Wilks' Lambda	.738	.274(a)	6.000	10.000	.937
	Hotelling's Trace	.347	.232	6.000	8.000	.954
	Roy's Largest Root	.323	.646(b)	3.000	6.000	.613
a Exact statistic						
b The statistic is an upper bound on F that yields a lower bound on the significance level.						
c Design: Intercept+EXPERBIN Within Subjects Design: FRZ_PT						

Table 7. Multivariate Effect of Freeze Point with Experience on EB Page Percent of Time

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
FRZ_PT	Pillai's Trace	.411	1.743(a)	2.000	5.000	.267	.411
	Wilks' Lambda	.589	1.743(a)	2.000	5.000	.267	.411
	Hotelling's Trace	.697	1.743(a)	2.000	5.000	.267	.411
	Roy's Largest Root	.697	1.743(a)	2.000	5.000	.267	.411
FRZ_PT * EXPERBIN	Pillai's Trace	1.197	2.981	6.000	12.000	.051	.598
	Wilks' Lambda	.158	2.524(a)	6.000	10.000	.094	.602
	Hotelling's Trace	3.076	2.050	6.000	8.000	.171	.606
	Roy's Largest Root	1.884	3.768(b)	3.000	6.000	.078	.653
a Exact statistic							
b The statistic is an upper bound on F that yields a lower bound on the significance level.							
c Design: Intercept+EXPERBIN Within Subjects Design: FRZ_PT							

Table 8. Simultaneous Comparison of Freeze Point Means for Map Enable

(I) FRZ_PT	(J) FRZ_PT	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Lower Bound	Upper Bound
1	2	27.804	11.225	.144	-9.098	64.706
	3	21.479	14.802	.591	-27.183	70.141
2	1	-27.804	11.225	.144	-64.706	9.098
	3	-6.325	5.021	.764	-22.833	10.183
3	1	-21.479	14.802	.591	-70.141	27.183
	2	6.325	5.021	.764	-10.183	22.833

Based on estimated marginal means

a Adjustment for multiple comparisons: Bonferroni.

BIBLIOGRAPHY

B-1B Human Factors Baseline Study Report, ASC-TR-1999-5007, Kalman, Kline, Provost, Gable, & Taylor, 1999.

Statistical Package for the Social Sciences (SPSS) for Windows, SPSS INC., Chicago, IL., 1998.

"Subjective Workload Assessment Technique (SWAT): A Users Guide (U)," AAMRL-TR-89-023, Reid, Potter, & Bressler, 1989.

Questionnaire Construction Manual, Research Product 89-20, Fort Hood Field Unit Systems Research Laboratory, U.S. Army Research Institute for the Behavioral and Social Sciences, June, 1989. See also Annex in Research Product 89-21.

LIST OF ACRONYMS

ALT LAR	Alternative Launch Acceptability Region
CMUP	Conventional Mission Upgrade Program
CSEF	Crew Station Evaluation Facility
CSWG	Crew Station Working Group
DMPI	Desired Mean Point of Impact
DSO	Defensive System Operator
DSUP	Defensive System Upgrade Program
E page	Target Summary Display
EB page	LAR Status Display
ERS	Engineering Research Simulator
GPS	Global Positioning System
INS	Inertial Navigation System
JDAM	Joint Direct Attack Munition
LAR	Launch Acceptability Region
MFD	Multi-Function Display
Nav Prime	Primary Navigation
OSO	Offensive Systems Operator
RWR	Radar Warning Receiver
SPO	System Program Office
SWAT	Subjective Workload Assessment Technique
TTG	Time-To-Go
WSO	Weapons Systems Operators